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# A REVIEW

OF THE ARTICLE  
OF  
PROFESSOR

J. J. THOMSON,  
OXFORD  
UNIVERSITY,  
ENGLAND,  
ON

CATHODE  
RAYS, &c.

IN  
HARPER'S  
MAGAZINE  
FOR  
SEPTEMBER,  
1901.

BY JOSEPH BATTELL

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# CATHODE RAYS.

A REVIEW OF PROF. J. J. THOMSON'S ARTICLE ON  
CATHODE RAYS IN HARPER'S MAGAZINE  
FOR SEPTEMBER, 1901.

[FROM THE MIDDLEBURY (VT.) REGISTER]

(DECEMBER 27, 1901.)

BY JOSEPH BATTELL, AUTHOR OF "ELLEN."

Under the heading "Silence Gives Consent," Mr Joseph Battell says in his paper, the Middlebury Register:

A few weeks since we sent a copy of "Ellen" to Prof. J. J. Thomson of Oxford University, England, saying in a letter, that we perceived from his article in Harper's Magazine of September that he had abandoned the undulatory theories. We received very courteous acknowledgment of the book with silence in regard to the undulatory theories, which practically leaves it that the greatest physicist in the world is now on the right side of this question.

Silence gives consent in some cases; but we think that as a general rule philosophers and physicists are hardly willing to be considered to assent to every theory concerning which they do not care to express themselves. As to Prof. Thomson, we do not perceive from anything that he has said that he has definitely abandoned the undulatory theory. What he says in his article in Harper's, in which he develops the idea that the cathode rays consist of infinitesimal particles moving with immense rapidity, is:

Although in consequence of the universal acceptance of the undulatory theory of light a ray is generally associated in the minds of physicists with an undulatory motion in the ether, this association is only accidental and there is no necessary connection between a ray and undulatory motion; indeed Nelson uses the term in connection with his corpuscular theory of light.

If there is an accidental connection between rays of light and undulatory motion in the ether, it would seem to follow that there must be the undulations to be so connected. Prof. Thomson may be on the right side of the question; but it is not as yet plain that he is on Mr. Battell's side.

The above is from the Burlington Free Press of Dec. 24.

In heading the article referred to in Middlebury REGISTER, "Silence Gives

Consent," we did so deliberately, recognizing to its fullest extent the force of the proverb. For it is entirely evident to any one who reads Mr. Thomson's article on cathode rays which appeared in the September number of Harper's Magazine, that Prof. Thomson has abandoned the undulatory theory of light, and therefore of necessity must soon abandon, if he has not already, the undulatory theory of sound, and all other undulatory theories. For every intelligent physicist knows that whatever the laws may be, the same laws govern both light and sound.

The Free Press quotes a single passage from Prof. Thomson's article. In this passage, by typographical error in the Harper's, Mr. Newton's name is spelled Nelson. In the first place this should have been corrected by the Free Press, to give force to the paragraph, for it was Sir Isaac Newton and not Admiral Nelson or any other Nelson, who formulated the corpuscular theory of light. And it is well to notice here, that in returning to this theory we are following Mr. Newton, a great man, and a great physicist, instead of innumerable small men, who have left his instruction, fully convinced that they were "bigger than old Grant," and blind leaders of the blind, have lead the world of scientists into a ditch.

Had Mr. Newton lived we have no question that he would have easily sustained his theory. Unfortunately such men die, when incompetency in the guise of those who do not know but

think they do, runs away with the team. Had then Mr. Newton lived the world would have been saved in these regards a hundred years or more of lost time in chasing the will-o'-the-wisp of error.

In the paragraph quoted by the Free Press from Harper's Magazine, it will be perceived that Prof. Thomson says that "there is no necessary connection between a ray and undulatory motion" which could only be true when the undulatory theory of light was untrue. That is to say Mr. Thomson makes here a distinct statement,—and we believe that this was done deliberately and not accidentally,—that the undulatory theory of light is not true.

It is certainly, as we have said, entirely evident from the tenor of his whole article, what his real opinion is in regard to these undulatory theories, and we do not think it is too strong to say that it is one of absolute horror and disgust. It certainly is not too much to say that it is one of entire disbelief and abandonment.

As this article of Prof. Thomson's is both a very able and important one, unquestionably pointing the way to the great revolution now taking place in the physics of the world, we will examine more intimately what he says. The first sentence is revolutionary. It is this:

"The study of the effects which occur when a current of electricity passes through gas at a very low pressure has recently led to results having a very direct bearing on our ideas of matter and electricity."

If our ideas in regard to these subjects had undergone or were undergoing no change, why this sentence?

He goes on to show that the cathode rays are composed of material particles, which move in straight lines, like all other light, and the conclusion of the quotation made by the Free Press ending as they give it with a comma, is: "and the cathode rays, as we shall see, have an extraordinary resemblance to the conditions postulated in that (Newton's) theory for a ray of light."

That is, this quotation in full would read:

Although in consequence of the universal acceptance of the undulatory theory of light a ray is generally associated in the minds of physicists with an undulatory motion in the ether, this association is only accidental and there is no necessary connection between a ray and undulatory motion; indeed Nelson uses the term in connection with his corpuscular theory of light, and the cathode rays, as we shall see, have an extraordinary resemblance to the conditions postulated in that theory for a ray of light.

Prof. Thomson then goes on to show that cathode rays, like the ordinary rays of light, heat bodies on which they fall, may be focussed so as to raise a piece of platinum foil to a white heat, and even char a diamond.

He also states that, "The rays when they strike an object tend to push it away, the object behaving just as if it was struck by a stream of particles coming from the cathode. This is prettily shown in the experiment due to Sir William Crookes, when the impact of the rays makes the little carriage move from one end to the other of the rails."

This, too, is illustrated in the Crookes radiometers where small discs, fastened to an axis, are made to revolve slowly or with great rapidity according to the size of the stream of particles influencing them. And the effect is almost instantaneous, coming from sunlight or a lamp or heat rays of a stove. Of course in all these cases the stream of particles must enter the vacuum through the glass.

But the interstellar space is a vast region into which the air does not enter, and therefore similar to what we call a vacuum. It would appear to follow with absolute certainty that the vast stream of corpuscles of light and heat constantly emitted from the sun with their marvellous velocity of 186,000 miles per second must move all bodies in their path, which means especially the earth and planets, or what we call the solar system.

As light rays move in straight lines the result of this would be to push the planets away from the sun. This is the force of repulsion so-called. But Prof. Thomson shows that magnetism, which is unquestionably a stream of particles but

from another source, deflects the corpuscles of light from a straight to a curved course. Let then these two forces of light and magnetism be properly adjusted and the revolution of planets about their central sun is accounted for.

It will be well to remember here that Mr. Newton, as well as Kepler and others of the greatest thinkers on these subjects, supposed gravitation to be caused by some subtle medium.

Thus in a letter to Mr. Bentley, Mr. Newton says:

\* \* That gravity should be innate, inherent, and essential to matter, so that one body can act upon another at a distance, through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it."

Prof. Maxwell, in commenting upon this letter, says in the *Encyclopedia Britannica*.

"And we also know that he sought for the mechanism of gravitation in the properties of an ætherial medium diffused over the universe.

It appears from his letters to Boyle, that this was his opinion early, and if he did not publish it sooner it proceeded from hence only, that he found he was not able, from experiment and observation, to give a satisfactory account of this medium and the manner of its operation in producing the chief phenomena of nature."

And so, too, Mr. Newton in the first chapter of his "*Principia*" most particularly denies any intention to declare causes of the principles he refers to by the words chosen. Thus he says:

"I likewise call reactions and impulses, in the same sense, accelerative, and motive; and use the words attraction, impulse or propensity of any sort towards a center, promiscuously, and indifferently, one for another, considering those forces not physically, but mathematically: wherefore, the reader is not to imagine, that by those words, I anywhere take upon me to define the kind, or the manner of any action, the causes or the physical reason thereof, or that I attribute forces, in a true and physical sense, to certain centres (which are only mathematical); when at any time I happen to speak of centres as attracting, or as endued with attractive powers."

Another very remarkable thing referred to by Prof. Thomson is that these rays affect the color of substances, and this appears in such a way as certainly

to suggest that they have the power of imparting color; that is that they are the color giving substances. It is indeed a most beautiful thought that these infinitely small particles, which Prof. Thomson says are not over one one-thousandth of an atom of hydrogen in size, are the pigment or part of the pigment that gives the beautiful colors of the universe, those which hover upon the border of the clouds, or those which nestle in the exquisitely sweet petals of a rose. In His great universe, God certainly has such a pigment, or as many of them as may be wanted, and that they are of the character of these particles is now most highly probable.

Prof. Thomson says, "That some substances such as salt experience a peculiar change in color when exposed to these rays; crystals of rock salt become a pretty violet blue, looking almost like gems—the color is unfortunately somewhat fugative if the crystals are exposed to a moist atmosphere. Some, however, in my possession, which have been kept dry, are still blue, although they are now nearly four years old."

Prof. Thomson dwells further upon this color-producing quality and then says: "that the cathode Roentgen rays have many points of resemblance, they both affect a photographic plate, [all light does this,] they both cause substances against which they strike to phosphoresce, and they both make gas through which they pass a conductor of electricity. The cathode rays, too, as we shall see, have some power of penetrating opaque solids, though this is small compared with that possessed by the Roentgen rays; the essential difference between the two rays are that the Roentgen rays are not affected by a magnet, nor by an electric force, nor do they carry with them a charge of electricity."

Mr. Thomson states that physicists until three or four years ago were very much divided in opinion as to cathode rays; the German physicists, with very few exceptions, holding that they were waves of ether, but the English

physicists almost unanimously regarding them as particles of gas projected with great velocity. In 1892 Hertz showed that solids were not absolutely impenetrable by these rays. Lenard made a tube which had in it a small window of very thin aluminum foil, and shooting the cathode rays against this window they penetrated it so as to be investigated on the outside.

After this time, Mr. Thomson says, all the evidence was in favor of the particle theory, and "showed that the particles of the cathode rays are not ordinary atoms or molecules at all, but something very much smaller, for the mass of each particle is only about one thousandth part of that of the atom of hydrogen, the smallest mass hitherto recognized."

Mr. Thomson further says that this extreme smallness is not the only remarkable feature about these particles; "for it was found that whatever might be the form of the gas in the tube, or whatever metal was used for the cathode, the mass of the particles remained the same. That thus in these particles we have something possessing the properties of ordinary matter, having a definite mass, which is yet exceedingly small compared with the mass of any known element; the particles of this new kind of matter thus correspond to a very much finer state of subdivision than that of ordinary matter into its molecules."

He then refers to their speed as being enormous, and says: "The only velocity with which we can compare these particles is the velocity of light, which is about 186,000 miles per second." And these particles, be it remembered, are light. He then adds: "Thus in the tube near the cathode we have bodies smaller than atoms moving with prodigious velocities, a state of things which recalls Newton's corpuscular theory of light, according to which light consists of very small particles (corpuscles) moving at the rate of 186,000 miles per second. Although this theory of light has since been abandoned, Newton's conception is realized in the cathode rays; and I have

ventured to call the small particles which constitute these rays, corpuscles." One must be exceedingly stupid or ignorant, or both, who in reading this article has not by this time perceived that Mr. Thomson has abandoned the undulatory theories and *knows* that Newton's corpuscular theory of light is correct. This is what has been demonstrated by the experiments. Certainly he has abandoned the undulatory theory of light, and it won't take him long to abandon the others, if he has not already.

Prof. Thomson now calls attention to the fact that matter in the corpuscular state is not confined to the cathode rays in an exhausted tube, for he says when a metal wire is made red hot in a good vacuum, matter in this state is given off. He also says that it is given off when the metal, instead of being made red hot, is exposed to a bright light. He then refers to the fact that in these cases we get negative electricity in the gas around the wire; and in fact that whenever we have negative electricity in a gas at a very low pressure, where there is very little matter in the ordinary state for it to stick to, we find the electricity is carried by the corpuscles. He shows that when the pressure of the gas is not low, that is, when the air particles have not been thoroughly exhausted, that the corpuscles adhere to the molecules of gas. And therefore, he says, if we wish to get matter in this corpuscular state we must remove as much of the gas as possible; and that then we find that the negative electricity is always carried by these corpuscles. With positive electricity this is different, for this is always found on matter in the ordinary state, while negative electricity is found on corpuscles.

Prof. Thomson adds that this difference between the two electricities is just that which ought to exist on the one-fluid theory of electricity due to Benjamin Franklin. That according to that theory electricity was supposed to be a fluid; that when matter in the ordinary state contained a certain quantity of this fluid, it was said to be saturated, and not electrified; that if some of the fluid left

it so that it contained less than the normal quantity, it was charged with electricity of one sign; that if some fluid came into it so that it contained more than the normal quantity, it was charged with electricity of the opposite sign. And he then says:

"Now if we suppose that the electric fluid consists of a collection of our corpuscles, the results of our experiments will be exactly expressed by Franklin's one-fluid theory, and it would thus seem that there is some warrant for the somewhat discredited electric fluid.

"If the material of the cathode rays forms negative electricity, it is evident that it must be very widely spread; we have seen that it occurs free near white hot metals and metals exposed to the light. We may suppose that it forms a part of all kinds of matter in the normal state, and that the heat and light which have to be applied to metals are only required to get the corpuscles out of the metal, and that in the metal itself, even under normal conditions, there are corpuscles moving freely about, and able to carry heat as well as electricity from one part of the metal to the other."

Prof. Thomson then shows that there are some substances which constantly emit cathode rays without the aid of heat or light. He especially mentions uranium and a new substance called radium obtained from the mineral pitchblende. Radium, he says, has been shown to emit corpuscles at about two-thirds the velocity of light. And he adds:

"Since corpuscles are emitted by hot metals, it seems not improbable that that very hot body, the sun, may be emitting corpuscles, some of which would strike the earth, where, stopped by the earth's atmosphere, and deflected by the earth's magnetic force, they would produce luminosity in the upper region of the earth's atmosphere, which they would make a conductor of electricity."

And he adds that the consequences of such an emission of corpuscles by the sun have been investigated by several eminent physicists who have shown that

very many of the properties of the aurora borealis can be thus explained.

In conclusion he says:

"If this view is sustained by future investigations, we shall have to regard the corpuscles as playing an important part in cosmical as well as in terrestrial physics. The possibility of such a widespread scope for their action lends increased interest and importance to the investigation of their properties.

"It is a striking instance of the unity of physical phenomena on the smallest and largest scale that an occurrence apparently so exceptional as the glowing of the glass in a small tube should be closely connected with some of the most widespread phenomena in nature, and give the clew to their explanation."

We have thus given a synopsis of this very remarkable and most timely article of Prof. Thomson, which like a great guide board points the way to the physics of the future, suggesting the explanation of every hidden element or so-called force in the physics of the past, and from the standpoint of experiment demonstrating that all things in the universe are made by one law, the combination of what we call matter in its different conditions and proportions.

This indeed is a self evident proposition, for it is simply the carrying out of the fundamental principle of science, the universality of natural law; a principle as we have before had occasion to say sustained by every known fact in the universe. The only wonder is that science should have been so slow to perceive the logic of its own teaching. We may well thank God and take courage that we are emerging from this dark age of science, and coming upon that great and broad ocean of Truth, where religion and science will be exactly blended, teaching as they should precisely the same thing, and what the Bible and all true religion has always taught, that all things are created by an infinite and personal God; that the order and nature of their creation is precisely the same that we see carried out in the things made by man, who is created after the image of God, and therefore must

work, if he works at all, in accordance with the laws of an infinite Creator, who not only has appointed the laws which govern every substance in the universe, but has also created both those substances and the matter from which they are made.

And these great truths will assuredly lead to a better understanding of the

laws which control our moral and religious being, which also are unfolded in the Bible, and show that there is a connection between this and another life, as concise and definitely marked out, as are the boundaries of these various physical elements which we have been considering.